

3-30-00

Practitioner's Docket No. 460-009334-US(PAR)

PATENT

Preliminary Classification:

Proposed Class:

Subclass:

NOTE: "All applicants are requested to include a preliminary classification on newly filed patent applications. The preliminary classification, preferably class and subclass designations, should be identified in the upper right-hand corner of the letter of transmittal accompanying the application papers, for example 'Proposed Class 2, subclass 129.'" M.P.E.P. § 601, 7th ed.

jc598 U.S. PTO  
09/537501  
03/29/00

## IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Box Patent Application  
Assistant Commissioner for Patents  
Washington, D.C. 20231

## NEW APPLICATION TRANSMITTAL

Transmitted herewith for filing is the patent application of

Inventor(s): OTTI TALVITIE, Saku LAHTI, Petri KOTILAINEN, Masawan RAMESH

WARNING: 37 C.F.R. § 1.41(a)(1) points out:

"(a) A patent is applied for in the name or names of the actual inventor or inventors.

"(1) The inventorship of a nonprovisional application is that inventorship set forth in the oath or declaration as prescribed by § 1.63, except as provided for in § 1.53(d)(4) and § 1.63(d). If an oath or declaration as prescribed by § 1.63 is not filed during the pendency of a nonprovisional application, the inventorship is that inventorship set forth in the application papers filed pursuant to § 1.53(b), unless a petition under this paragraph accompanied by the fee set forth in § 1.17(f) is filed supplying or changing the name or names of the inventor or inventors."

For (title): SYSTEM FOR MATCHING AN ANTENNA FOR A WIRELESS COMMUNICATION DEVICE

**CERTIFICATION UNDER 37 C.F.R. § 1.10\***  
(Express Mail label number is mandatory.)  
(Express Mail certification is optional.)

I hereby certify that this New Application Transmittal and the documents referred to as attached therein are being deposited with the United States Postal Service on this date 29 March 2000, in an envelope as "Express Mail Post Office to Addressee," mailing Label Number EL336863522US, addressed to the: Assistant Commissioner for Patents, Washington, D.C. 20231.

June Adams

(type or print name of person mailing paper)



Signature of person mailing paper

WARNING: Certificate of mailing (first class) or facsimile transmission procedures of 37 C.F.R. § 1.8 cannot be used to obtain a date of mailing or transmission for this correspondence.

WARNING: Each paper or fee filed by "Express Mail" must have the number of the "Express Mail" mailing label placed thereon prior to mailing. 37 C.F.R. § 1.10(b).

"Since the filing of correspondence under § 1.10 without the Express Mail mailing label thereon is an oversight that can be avoided by the exercise of reasonable care, requests for waiver of this requirement will not be granted on petition." Notice of Oct. 24, 1996, 60 Fed. Reg. 56,439, at 56,442.

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jc780 U.S. PTO  
03/29/00

09537501.032900

**1. Type of Application**

This new application is for a(n)

(check one applicable item below)

- ☒ Original (nonprovisional)  
☐ Design  
☐ Plant

**WARNING:** Do not use this transmittal for a completion in the U.S. of an International Application under 35 U.S.C. § 371(c)(4), unless the International Application is being filed as a divisional, continuation or continuation-in-part application.

**WARNING:** Do not use this transmittal for the filing of a provisional application.

**NOTE:** If one of the following 3 items apply, then complete and attach **ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF A PRIOR U.S. APPLICATION CLAIMED** and a **NOTIFICATION IN PARENT APPLICATION OF THE FILING OF THIS CONTINUATION APPLICATION**.

- ☐ Divisional.  
☐ Continuation.  
☐ Continuation-in-part (C-I-P).

**2. Benefit of Prior U.S. Application(s) (35 U.S.C. §§ 119(e), 120, or 121)**

**NOTE:** A nonprovisional application may claim an invention disclosed in one or more prior filed copending nonprovisional applications or copending international applications designating the United States of America. In order for a nonprovisional application to claim the benefit of a prior filed copending nonprovisional application or copending international application designating the United States of America, each prior application must name as an inventor at least one inventor named in the later filed nonprovisional application and disclose the named inventor's invention claimed in at least one claim of the later filed nonprovisional application in the manner provided by the first paragraph of 35 U.S.C. § 112. Each prior application must also be:

(i) An international application entitled to a filing date in accordance with PCT Article 11 and designating the United States of America; or

(ii) Complete as set forth in § 1.51(b); or

(iii) Entitled to a filing date as set forth in § 1.53(b) or § 1.53(d) and include the basic filing fee set forth in § 1.16; or

(iv) Entitled to a filing date as set forth in § 1.53(b) and have paid therein the processing and retention fee set forth in § 1.21(f) within the time period set forth in § 1.53(f).

37 C.F.R. § 1.78(a)(1).

**NOTE:** If the new application being transmitted is a divisional, continuation or a continuation-in-part of a parent case, or where the parent case is an International Application which designated the U.S., or benefit of a prior provisional application is claimed, then check the following item and complete and attach **ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED**.

**WARNING:** If an application claims the benefit of the filing date of an earlier filed application under 35 U.S.C. §§ 120, 121 or 365(c), the 20-year term of that application will be based upon the filing date of the earliest U.S. application that the application makes reference to under 35 U.S.C. §§ 120, 121 or 365(c). (35 U.S.C. § 154(a)(2) does not take into account, for the determination of the patent term, any application on which priority is claimed under 35 U.S.C. §§ 119, 365(a) or 365(b).) For a c-i-p application, applicant should review whether any claim in the patent that will issue is supported by an earlier application and, if not, the applicant should consider canceling the reference to the earlier filed application. The term of a patent is not based on a claim-by-claim approach. See Notice of April 14, 1995, 60 Fed. Reg. 20,195, at 20,205.

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**WARNING:** When the last day of pendency of a provisional application falls on a Saturday, Sunday, or Federal holiday within the District of Columbia, any nonprovisional application claiming benefit of the provisional application must be filed prior to the Saturday, Sunday, or Federal holiday within the District of Columbia. See 37 C.F.R. § 1.78(a)(3).

- ☐ The new application being transmitted claims the benefit of prior U.S. application(s). Enclosed are ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED.

**3. Papers Enclosed**

- A.** Required for filing date under 37 C.F.R. § 1.53(b) (Regular) or 37 C.F.R. § 1.153 (Design) Application

17 Pages of specification

3 Pages of claims

7 Sheets of drawing

**WARNING:** DO NOT submit original drawings. A high quality copy of the drawings should be supplied when filing a patent application. The drawings that are submitted to the Office must be on strong, white, smooth, and non-shiny paper and meet the standards according to § 1.84. If corrections to the drawings are necessary, they should be made to the original drawing and a high-quality copy of the corrected original drawing then submitted to the Office. Only one copy is required or desired. For comments on proposed then-new 37 C.F.R. § 1.84, see Notice of March 9, 1988 (1990 O.G. 57-62).

**NOTE:** "Identifying indicia, if provided, should include the application number or the title of the invention, inventor's name, docket number (if any), and the name and telephone number of a person to call if the Office is unable to match the drawings to the proper application. This information should be placed on the back of each sheet of drawing a minimum distance of 1.5 cm. (5/8 inch) down from the top of the page . . ." 37 C.F.R. § 1.84(c).

(complete the following, if applicable)

- ☐ The enclosed drawing(s) are photograph(s), and there is also attached a "PETITION TO ACCEPT PHOTOGRAPH(S) AS DRAWING(S)." 37 C.F.R. § 1.84(b).

☐ formal

☐ Informal

**B. Other Papers Enclosed**

8 Pages of declaration and power of attorney

1 Pages of abstract

     Other

**4. Additional papers enclosed**

- ☐ Amendment to claims

☐ Cancel in this applications claims \_\_\_\_\_ before calculating the filing fee. (At least one original independent claim must be retained for filing purposes.)

☐ Add the claims shown on the attached amendment. (Claims added have been numbered consecutively following the highest numbered original claims.)

☒ Preliminary Amendment

☒ Information Disclosure Statement (37 C.F.R. § 1.98)

☒ Form PTO-1449 (PTO/SB/08A and 08B)

☒ Citations

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- ☐ Declaration of Biological Deposit
- ☐ Submission of "Sequence Listing," computer readable copy and/or amendment pertaining thereto for biotechnology invention containing nucleotide and/or amino acid sequence.
- ☐ Authorization of Attorney(s) to Accept and Follow Instructions from Representative
- ☐ Special Comments
- ☐ Other

**5. Declaration or oath (including power of attorney)**

**NOTE:** A newly executed declaration is not required in a continuation or divisional application provided that the prior nonprovisional application contained a declaration as required, the application being filed is by all or fewer than all the inventors named in the prior application, there is no new matter in the application being filed, and a copy of the executed declaration filed in the prior application (showing the signature or an indication thereon that it was signed) is submitted. The copy must be accompanied by a statement requesting deletion of the names of person(s) who are not inventors of the application being filed. If the declaration in the prior application was filed under § 1.47, then a copy of that declaration must be filed accompanied by a copy of the decision granting § 1.47 status or, if a nonsigning person under § 1.47 has subsequently joined in a prior application, then a copy of the subsequently executed declaration must be filed. See 37 C.F.R. §§ 1.63(d)(1)-(3).

**NOTE:** A declaration filed to complete an application must be executed, identify the specification to which it is directed, identify each inventor by full name including family name and at least one given name, without abbreviation together with any other given name or initial, and the residence, post office address and country or citizenship of each inventor, and state whether the inventor is a sole or joint inventor. 37 C.F.R. § 1.63(a)(1)-(4).

☒ Enclosed

Executed by

(check all applicable boxes)

☒ Inventor(s).

☐ legal representative of inventor(s).  
37 C.F.R. §§ 1.42 or 1.43.

☐ joint inventor or person showing a proprietary interest on behalf of inventor who refused to sign or cannot be reached.

☐ This is the petition required by 37 C.F.R. § 1.47 and the statement required by 37 C.F.R. § 1.47 is also attached. See item 13 below for fee.

☐ Not Enclosed.

**NOTE:** Where the filing is a completion in the U.S. of an International Application or where the completion of the U.S. application contains subject matter in addition to the International Application, the application may be treated as a continuation or continuation-in-part, as the case may be, utilizing ADDED PAGE FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION CLAIMED.

☐ Application is made by a person authorized under 37 C.F.R. § 1.41(c) on behalf of all the above named inventor(s).

(The declaration or oath, along with the surcharge required by 37 C.F.R. § 1.16(e) can be filed subsequently).

☐ Showing that the filing is authorized.  
(not required unless called into question. 37 C.F.R. § 1.41(d))

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006220" T05/2550

## 6. Inventorship Statement

**WARNING:** If the named inventors are each not the inventors of all the claims an explanation, including the ownership of the various claims at the time the last claimed invention was made, should be submitted.

The inventorship for all the claims in this application are:

☐ The same.

or

☐ Not the same. An explanation, including the ownership of the various claims at the time the last claimed invention was made,

☐ is submitted.

☐ will be submitted.

## 7. Language

**NOTE:** An application including a signed oath or declaration may be filed in a language other than English. An English translation of the non-English language application and the processing fee of \$130.00 required by 37 C.F.R. § 1.17(k) is required to be filed with the application, or within such time as may be set by the Office. 37 C.F.R. § 1.52(d).

☒ English

☐ Non-English

☐ The attached translation includes a statement that the translation is accurate. 37 C.F.R. § 1.52(d).

## 8. Assignment

☒ An assignment of the invention to Nokia Mobile Phones Ltd.

☒ is attached. A separate ☒ "COVER SHEET FOR ASSIGNMENT (DOCUMENT) ACCOMPANYING NEW PATENT APPLICATION" or ☐ FORM PTO 1595 is also attached.

☐ will follow.

**NOTE:** "If an assignment is submitted with a new application, send two separate letters—one for the application and one for the assignment." Notice of May 4, 1990 (1114 O.G. 77-78).

**WARNING:** A newly executed "CERTIFICATE UNDER 37 C.F.R. § 3.73(b)" must be filed when a continuation-in-part application is filed by an assignee. Notice of April 30, 1993, 1150 O.G. 62-64.

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005220" T0545560

**9. Certified Copy**

Certified copy(ies) of application(s)

Country	Appln. No.	Filed
Finland	990687	29 March 1999
Country	Appln. No.	Filed
Country	Appln. No.	Filed

from which priority is claimed

☒ Is (are) attached.☐ will follow.

NOTE: The foreign application forming the basis for the claim for priority must be referred to in the oath or declaration. 37 C.F.R. § 1.55(a) and 1.63.

NOTE: This item is for any foreign priority for which the application being filed directly relates. If any parent U.S. application or International Application from which this application claims benefit under 35 U.S.C. § 120 is itself entitled to priority from a prior foreign application, then complete Item 18 on the ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED.

**10. Fee Calculation (37 C.F.R. § 1.16)**A. ☒ Regular application

CLAIMS AS FILED						
Number filed			Number Extra	Rate		Basic Fee 37 C.F.R. § 1.16(a) \$ 690.00
Total						
Claims (37 C.F.R. § 1.16(c))	15	— 20 =	0	×	\$ 18.00	0
Independent						
Claims (37 C.F.R. § 1.16(b))	3	— 3 =	0	×	\$ 78.00	0
Multiple dependent claim(s), If any (37 C.F.R. § 1.16(d))						
				+	\$260.00	

☐ Amendment cancelling extra claims is enclosed.☒ Amendment deleting multiple-dependencies is enclosed.☐ Fee for extra claims is not being paid at this time.

NOTE: If the fees for extra claims are not paid on filing they must be paid or the claims cancelled by amendment, prior to the expiration of the time period set for response by the Patent and Trademark Office in any notice of fee deficiency. 37 C.F.R. § 1.16(d).

Filing Fee Calculation

\$ 690.00

B. ☐ Design application  
(\$310.00—37 C.F.R. § 1.16(f))

Filing Fee Calculation

\$

C. ☐ Plant application  
(\$480.00—37 C.F.R. § 1.16(g))

Filing fee calculation

\$

11. Small Entity Statement(s)

- ☐ Statement(s) that this is a filing by a small entity under 37 C.F.R. § 1.9 and 1.27 is (are) attached.

**WARNING:** "Status as a small entity must be specifically established in each application or patent in which the status is available and desired. Status as a small entity in one application or patent does not affect any other application or patent, including applications or patents which are directly or indirectly dependent upon the application or patent in which the status has been established. The refiling of an application under § 1.53 as a continuation, division, or continuation-in-part (including a continued prosecution application under § 1.53(d)), or the filing of a reissue application requires a new determination as to continued entitlement to small entity status for the continuing or reissue application. A nonprovisional application claiming benefit under 35 U.S.C. § 119(e), 120, 121, or 365(c) of a prior application, or a reissue application may rely on a statement filed in the prior application or in the patent if the nonprovisional application or the reissue application includes a reference to the statement in the prior application or in the patent or includes a copy of the statement in the prior application or in the patent and status as a small entity is still proper and desired. The payment of the small entity basic statutory filing fee will be treated as such a reference for purposes of this section." 37 C.F.R. § 1.28(a)(2).

**WARNING:** "Small entity status must not be established when the person or persons signing the . . . statement can unequivocally make the required self-certification." M.P.E.P., § 509.03, 6th ed., rev. 2, July 1996 (emphasis added).

(complete the following, if applicable)

- ☐ Status as a small entity was claimed in prior application  
\_\_\_\_\_ / \_\_\_\_\_, filed on \_\_\_\_\_, from which benefit  
is being claimed for this application under:

35 U.S.C. § ☐ 119(e),  
☐ 120,  
☐ 121,  
☐ 365(c),

and which status as a small entity is still proper and desired.

- ☐ A copy of the statement in the prior application is included.

Filing Fee Calculation (50% of A, B or C above)

\$ \_\_\_\_\_

**NOTE:** Any excess of the full fee paid will be refunded if small entity status is established and a refund request are filed within 2 months of the date of timely payment of a full fee. The two-month period is not extendable under § 1.136. 37 C.F.R. § 1.28(a).

12. Request for International-Type Search (37 C.F.R. § 1.104(d))

(complete, if applicable)

- ☐ Please prepare an international-type search report for this application at the time when national examination on the merits takes place.

13. Fee Payment Being Made at This Time

☐ Not Enclosed

☐ No filing fee is to be paid at this time.

*(This and the surcharge required by 37 C.F.R. § 1.16(e) can be paid subsequently.)*

☒ Enclosed

☒ Filing fee \$ 690.00

☒ Recording assignment  
(\$40.00; 37 C.F.R. § 1.21(h))  
(See attached "COVER SHEET FOR  
ASSIGNMENT ACCOMPANYING NEW  
APPLICATION".) \$ 40.00

☐ Petition fee for filing by other than all the  
inventors or person on behalf of the inventor  
where inventor refused to sign or cannot be  
reached  
(\$130.00; 37 C.F.R. §§ 1.47 and 1.17(l)) \$

☐ For processing an application with a  
specification in  
a non-English language  
(\$130.00; 37 C.F.R. §§ 1.52(d) and 1.17(k)) \$

☐ Processing and retention fee  
(\$130.00; 37 C.F.R. §§ 1.53(d) and 1.21(l)) \$

☐ Fee for international-type search report  
(\$40.00; 37 C.F.R. § 1.21(e)) \$

NOTE: 37 C.F.R. § 1.21(f) establishes a fee for processing and retaining any application that is abandoned for failing to complete the application pursuant to 37 C.F.R. § 1.53(f) and this, as well as the changes to 37 C.F.R. §§ 1.53 and 1.78(a)(1), indicate that in order to obtain the benefit of a prior U.S. application, either the basic filing fee must be paid, or the processing and retention fee of § 1.21(l) must be paid, within 1 year from notification under § 53(f).

Total fees enclosed \$ 730.00

14. Method of Payment of Fees

☒ Check in the amount of \$ 730.00

☐ Charge Account No. \_\_\_\_\_ in the amount of  
\$ \_\_\_\_\_

A duplicate of this transmittal is attached.

NOTE: Fees should be itemized in such a manner that it is clear for which purpose the fees are paid. 37 C.F.R. § 1.22(b).



**15. Authorization to Charge Additional Fees**

**WARNING:** If no fees are to be paid on filing, the following items should not be completed.

**WARNING:** Accurately count claims, especially multiple dependent claims, to avoid unexpected high charges, if extra claim charges are authorized.

- ☒ The Commissioner is hereby authorized to charge the following additional fees by this paper and during the entire pendency of this application to Account No. 16-1350:

☒ 37 C.F.R. § 1.16(a), (f) or (g) (filing fees)

☒ 37 C.F.R. § 1.16(b), (c) and (d) (presentation of extra claims)

**NOTE:** Because additional fees for excess or multiple dependent claims not paid on filing or on later presentation must only be paid or these claims cancelled by amendment prior to the expiration of the time period set for response by the PTO in any notice of fee deficiency (37 C.F.R. § 1.16(d)), it might be best not to authorize the PTO to charge additional claim fees, except possibly when dealing with amendments after final action.

☒ 37 C.F.R. § 1.16(e) (surcharge for filing the basic filing fee and/or declaration on a date later than the filing date of the application)

☒ 37 C.F.R. § 1.17(a)(1)-(5) (extension fees pursuant to § 1.136(a)).

☐ 37 C.F.R. § 1.17 (application processing fees)

**NOTE:** ". . . A written request may be submitted in an application that is an authorization to treat any concurrent or future reply, requiring a petition for an extension of time under this paragraph for its timely submission, as incorporating a petition for extension of time for the appropriate length of time. An authorization to charge all required fees, fees under § 1.17, or all required extension of time fees will be treated as a constructive petition for an extension of time in any concurrent or future reply requiring a petition for an extension of time under this paragraph for its timely submission. Submission of the fee set forth in § 1.17(a) will also be treated as a constructive petition for an extension of time in any concurrent reply requiring a petition for an extension of time under this paragraph for its timely submission." 37 C.F.R. § 1.136(a)(3).

☐ 37 C.F.R. § 1.18 (issue fee at or before mailing of Notice of Allowance, pursuant to 37 C.F.R. § 1.311(b))

**NOTE:** Where an authorization to charge the issue fee to a deposit account has been filed before the mailing of a Notice of Allowance, the issue fee will be automatically charged to the deposit account at the time of mailing the notice of allowance. 37 C.F.R. § 1.311(b).

**NOTE:** 37 C.F.R. § 1.28(b) requires "Notification of any change in status resulting in loss of entitlement to small entity status must be filed in the application . . . prior to paying, or at the time of paying, . . . the issue fee. . . ." From the wording of 37 C.F.R. § 1.28(b), (a) notification of change of status must be made even if the fee is paid as "other than a small entity" and (b) no notification is required if the change is to another small entity.

(New Application Transmittal [4-1]—page 9 of 11)

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**16. Instructions as to Overpayment**

*NOTE: "... Amounts of twenty-five dollars or less will not be returned unless specifically requested within a reasonable time, nor will the payer be notified of such amounts; amounts over twenty-five dollars may be returned by check or, if requested, by credit to a deposit account." 37 C.F.R. § 1.26(a).*

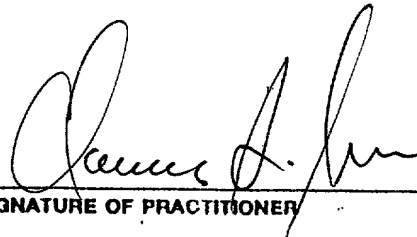
- ☒ Credit Account No. 16-1350  
☐ Refund

SEND ALL CORRESPONDENCE TO:

Reg. No. 24,622

Tel. No. (203) 259-1800

Customer No.



SIGNATURE OF PRACTITIONER

Clarence A. Green

(type or print name of attorney)

PERMAN & GREEN, LLP

P.O. Address

425 Post Road, Fairfield, Connecticut 06430

☐ **Incorporation by reference of added pages**

*(check the following item if the application in this transmittal claims the benefit of prior U.S. application(s) (including an international application entering the U.S. stage as a continuation, divisional or C-I-P application) and complete and attach the ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED)*

- ☐ Plus Added Pages for New Application Transmittal Where Benefit of Prior U.S. Application(s) Claimed

Number of pages added \_\_\_\_\_

- ☐ Plus Added Pages for Papers Referred to in Item 4 Above

Number of pages added \_\_\_\_\_

- ☐ Plus added pages deleting names of inventor(s) named in prior application(s) who is/are no longer inventor(s) of the subject matter claimed in this application.

Number of pages added \_\_\_\_\_

- ☐ Plus "Assignment Cover Letter Accompanying New Application"

Number of pages added \_\_\_\_\_

☒ **Statement Where No Further Pages Added**

*(if no further pages form a part of this Transmittal, then end this Transmittal with this page and check the following item)*

- ☒ This transmittal ends with this page.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Express Mail No.: EL336863522US

In re Application of: TALVITIE et al.

SERIAL NUMBER:

EXAMINER:

FILING DATE: Herewith

ART UNIT:

TITLE: SYSTEM FOR MATCHING AN ANTENNA FOR A WIRELESS  
COMMUNICATION DEVICE

ATTORNEY DOCKET NO.: 460-009334-US(PAR)

The Commissioner of Patents and Trademarks

Washington, D.C. 20231

**PRELIMINARY AMENDMENT**

Dear Sir:

Please amend the above-identified, enclosed patent application as follows:

**IN THE CLAIMS:**

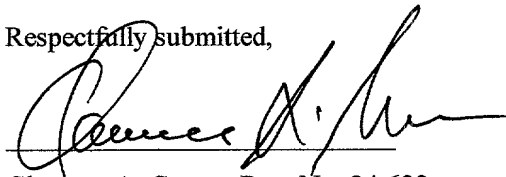
Please amend Claims 7, 9 and 10 as shown below.

Claim 7, lines 1 and 2, delete "5 or 5,".

Claim 9, lines 1 and 2, delete "any of the claims 4 to 8" and insert --claim 4--.

Claim 10, lines 1 and 2, delete "any of the claims 4 to 8" and insert --claim 4--.

Respectfully submitted,



Clarence A. Green, Reg. No. 24,622  
Perman & Green, LLP  
425 Post Road  
Fairfield, CT 06430  
(203) 259-1800

29 Mar 02

Date

006220" T052E560

## System for matching an antenna for a wireless communication device

5 The present invention relates to a system for matching an antenna for a wireless communication device. The invention relates also to a wireless communication device comprising at least an antenna, as well as a method for matching an antenna for a wireless communication device.

10 In most common mobile communication systems, a base transceiver station controls the transmission output on the basis of the level of the received signal. Close to the base transceiver station, the transmission output of the wireless communication device is small, whereas at the extreme limits of the service area, the transmission output of the wireless communication device is at its maximum. Consequently, the power consumption of the wireless communication device is highly dependent on the location of use of the device.

15 Also, various obstructions particularly in the direct vicinity of the wireless communication device suppress the signal of the transmitter. The base transceiver station compensates this attenuation by raising the transmission power of the wireless communication device. Thus, *e.g.* a poor position of use of the wireless communication device, such as the antenna too close to the user's head, may cause an unnecessary increase in the power consumption. The same problem occurs also  
20 when the user is turned so that his/her head is between the base transceiver station and the antenna of the wireless communication device.

25 A third factor affecting the strength of the signal received by the base transceiver station is the position of the antenna of the wireless communication device. The antennas of the base transceiver stations are typically directed to transmit and receive vertically polarized signals, wherein the signal received by the base transceiver station is at its strongest when the antenna of the wireless communication device is in the vertical position. If the user keeps the wireless communication device in an inclined or even horizontal position, the signal received by the base transceiver station is weakened, wherein the base transceiver station must increase the transmission power of the wireless communication device again.  
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5 For example, electroconductive objects, such as metal objects, in the vicinity of the wireless communication device may change the impedance of the antenna. The impedance of the antenna is also affected by the fact whether the wireless communication device is held in bare hands or in hands wearing gloves.

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position, wherein particularly in a weaker base station field, part of the incoming calls may be left undetected.

As an example, the appended Fig. 1 shows the antenna matching of a wireless communication device. Curve A illustrates the optimization of the matching for the standby state, and curve B the optimization of the matching for the use situation, respectively. In the coordinates, the horizontal axis represents the frequency and the vertical axis the matching on the basis of the output reflected from the antenna. The matching is the better the smaller part is reflected back from the antenna. From the curves of Fig. 1, it can be deduced *e.g.* that the optimal matching of the antenna in the standby position is at the frequencies of *ca.* 950 Mhz and *ca.* 1.75 GHz, and correspondingly in the use position at the frequencies of *ca.* 1.0 GHz and 1.8 GHz. In addition to the fact that the matching of the antenna is changed in different use positions, also the frequency at which the best matching is achieved is changed. This drawback can be reduced to some extent by optimizing the matching of the antenna in a way that it functions reasonably both in the standby position and in the use position, but then the matching of the antenna is not the best possible in either of the positions.

It is an aim of the present invention to present a system in which the matching of the antenna is adjusted to suit different positions of use, as well as a wireless communication device, in which the matching of the antenna is adjusted according to the use conditions. The invention is based on the idea of measuring at least the radio frequency reflected from the antenna and adjusting the matching of the antenna on the basis of this measurement. The matching system according to the present invention is characterized in that it comprises:

- detecting means to detect the matching of the antenna and to generate a matching signal on the basis of the detected matching,
- control means to examine said matching signal, to determine the need for matching, and to generate a control signal on the basis of said matching signal, and
- antenna matching means to adjust the matching of the antenna on the basis of said control signal.

The wireless communication device according to the present invention is characterized in that the wireless communication device also comprises:

- 5 — detecting means to detect the matching of the antenna and to generate a matching signal on the basis of the detected matching,
- control means to examine said matching signal, to determine the need for matching, and to generate a control signal on the basis of said matching signal, and
- 10 — antenna matching means to adjust the matching of the antenna on the basis of said control signal.

The method according to the present invention is characterized in that in the method, the matching of the antenna is detected, a matching  
15 signal is generated on the basis of the detected matching, said matching signal is examined to determine the need for matching the antenna, wherein a control signal is generated on the basis of said matching signal, and the matching of the antenna is adjusted on the basis of said control signal.

20 By using the present invention, considerable advantages are achieved in comparison with systems and wireless communication devices of prior art. In the wireless communication device according to the invention, different use positions can be taken into account in the design of the matching of the antenna, wherein in different situations of use of the  
25 wireless communication device, the matching of the antenna is as good as possible. Thus, the wireless communication device according to the invention functions well in the standby state also in a weak signal field and, correspondingly, in the use situation the quantity of radio output reflected back from the antenna is adjusted as small as possible,  
30 wherein it is possible to reduce the power consumption of the wireless communication device.

In the following, the invention will be described in more detail with reference to the appended drawings, in which

35 Fig. 1 shows the matching of a wireless communication device of prior art as a function of frequency in different functional positions,



Fig. 2 is a reduced block chart showing a wireless communication device according to an advantageous embodiment of the invention,

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Figs. 3a-3c show various matching circuits for an antenna,

Figs. 4a-4b show some advantageous examples of switch solutions to be used in connection with the antenna matching of the invention,

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Fig. 5 shows an output detecting connection according to prior art,

Fig. 6 is a reduced block chart showing a wireless communication device according to a second advantageous embodiment of the invention, and

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Fig. 7 is a perspective view showing a wireless communication device according to a third advantageous embodiment of the invention.

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Figure 2 is a reduced block chart showing a system according to an advantageous embodiment of the invention. The system comprises a directional coupler 1 which is placed in a transfer line between the power amplifier 2 and the duplex filter 3 of the transmitter. In the directional coupler 1, there are two outputs in addition to the connections of the transfer line, the signal level of the first output 1a being proportional to the signal level passing from the power amplifier 2 to the antenna ANT, and the signal level of the second output 1b being proportional to the signal level passing from the antenna ANT to the power amplifier 2, *i.e.* the signal level reflected from the antenna. The first output 1a is coupled to an outgoing power detector 4, and the second output 1b is coupled to a reflected power detector 5. In the output of the outgoing power detector 4 there is a DC (direct-current) voltage  $U_{ant}$  proportional to the power of the radio-frequency signal to be transmitted to the antenna, and in the output of the reflected power detector 5 there is a DC voltage  $U_{ref}$  proportional to the power of the radio-frequency signal reflected to the power amplifier 2. Figure 5 shows a detector

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coupling 4, 5 according to prior art, suitable for use in the system of the invention. The operation of this coupling is described in more detail in US patent 5,214,372. In the system of the invention, it is also possible to use any other measuring and detecting coupling of prior art. As an example, the use of a rectifier diode should be mentioned, wherein a pulsating DC voltage rectified with a diode is measured and used to determine the effective value. If necessary, it is also possible to use a capacitor in addition to the diode, to stabilize fluctuations in the voltage, which is known as such.

The DC voltage  $U_{ant}$  obtained from the output of the outgoing power detector 4 is led to a signal processing means 6, in which the voltage value is converted preferably to digital form and the effective value and/or short-term average of the voltage is calculated. In a corresponding manner, the DC voltage  $U_{ref}$  obtained from the output of the reflected power detector 5 is led to the signal processing means 6 and converted to digital form. Also from this DC voltage describing the reflected power quantity, the effective value and/or short-term average of the voltage is advantageously calculated. The effective and/or average values calculated from the voltages  $U_{ant}$ ,  $U_{ref}$  are led to a control means 7.

In the duplex filter 3, harmonic frequencies, *i.e.* multiples, of the signal to be transmitted are attenuated with a low pass filter 3a, and the signal to be transmitted is prevented from entering the receiver RX. The signal to be transmitted from the duplex filter is led via a supply line 10 to be transmitted to the antenna ANT.

In a corresponding manner at the receiving stage, the radio-frequency signals received from the antenna ANT are led via the supply line 10 to the duplex filter 3, in which a band-pass filter 3b is used to filter out frequencies outside the receiving frequency range. The radio-frequency signals within the receiving frequency range are led from the duplex filter 3 to the receiver RX to be received in a way known as such.

In a time division multiple access (TDMA) system, such as the GSM cellular system, each wireless communication device transmitting on the same radio channel in the area of the same cell is allocated certain

transmission time slots and certain receiving time slots, which are different, as is known as such. Thus, the control means 7 has information on the time slots in which the wireless communication device in question is allowed to transmit and the time slots in which the wireless communication device receives the radio signal transmitted by the base transceiver station. The adjustment of the matching of the control means 7 in the running application software can thus utilize this information to determine the correct moment of time for measuring the outgoing and reflected power. In a wireless communication device according to a second advantageous embodiment of the invention, this information is used to determine the moment of time at which the strength of the received signal is measured.

On the other hand, for example in a code division multiple access (CDMA) system, several wireless communication devices can transmit simultaneously, wherein the transmitting and reflected power can be measured substantially continuously during the connection.

The following is a description of the operation of the method according to a first advantageous embodiment of the invention in a wireless communication device MS. In the method, the adjustment of the matching is based on measuring the power reflected from the antenna during the transmission. In the adjustment, it is also possible to measure the power to be transferred from the power amplifier to the antenna of the transmitter. Upon starting the wireless communication device MS, a matching means 9 is set e.g. at a first matching value, which in this example is optimized as matching corresponding to the standby state of the antenna, but it can also be matching corresponding to e.g. the position of use of the antenna. The first matching value of the matching means 9 is set advantageously so that the control means 7 sets in the control line 8 of the matching means a first voltage value, such as a voltage value corresponding to the logical 0 state, which in the examples described in this specification corresponds to the voltage value of ca. 0 V. The application software of the control means 7 is equipped with a program for executing the matching. During the operation of the wireless communication device MS, the control means 7 runs this application program at intervals to examine and adjust the need for matching if necessary.

When the matching adjustment is made solely on the basis of the power reflected from the antenna, it can be implemented *e.g.* in the following way. The control means 7 sets in the control line 8 of the matching means a first voltage value, wherein a first matching value is set in the matching means 9. After this, the power of the reflected radio-frequency signal is determined by measuring the output voltage  $U_{\text{ref}}$  of the reflected power detector 5 at the stage when power is led to the antenna. On the basis of the measurement, in the signal processing means 6, the voltage is converted into digital format, and the effective value of the voltage is advantageously calculated and stored in memory means MEM, preferably in a random access memory (RAM). Next, the control means 7 sets in the control line 8 of the matching means a second voltage value, whereby a second matching value for the matching means 9 is selected for the matching means 9, after which the reflected power is measured again and the measurement result is stored in the memory means MEM. This second voltage value is preferably a voltage value corresponding to the logical 1 state, which in practical solutions normally corresponds approximately to the operating voltage, such as 3 V, 3.3 V or 5 V. After going through all the possible matching values of the matching means, the control means 7 compares the effective values calculated on the basis of the measurements with different matchings. On the basis of the comparison, the control means 7 sets in the control line 8 of the matching means the value which corresponds to the matching of the matching means 9 at which the effective value of the reflected radio-frequency signal was the lowest.

The change of the matching can also be implemented for example in such a way that the matching means 9 comprises two or several alternative matching circuits, of which one is selected at a time with a switch or the like. Thus, the matching control line 8 may comprise several lines, of which one or several are selected to be active, which results in the activation of the respective matching circuit. Also other known solutions can be applied in this context. The implementations of the matching means 9 to be applied in connection with the present invention will be described hereinbelow.

Because the use conditions of the antenna may change also during a call and in the standby state, it is reasonable to perform the measurements and control operations required for executing the matching at intervals. Thus, one criterion to change the matching can be that the quantity of the power to be reflected changes more than a predetermined threshold value, *e.g.* a certain decibel quantity, or that the quantity of the power to be reflected in relation to the output changes more than a predetermined threshold value. Thus, preferably the signal processing means 6 is used to measure at intervals the power reflected from the antenna, and if the reflected output exceeds the predetermined threshold value, the control means 7 changes the matching of the matching means 9. After this, a new determination is made on the reflected power and compared with the power according to the preceding matching. If the reflected power decreased with this new matching, the matching of the antenna is kept at this value. In another case, if there are only two matching alternatives in the matching means 9, the matching is returned back to the preceding matching value. However, if there are more than two matching alternatives in the matching means 9, the next matching alternative is set in the matching means 9 and a new step of determining and comparing the reflected power is made, until a matching is found again, at which the reflected power is the smallest.

In the evaluation of the need for adjusting the matching, it is also possible to utilize the power to be transmitted in addition to the power reflected from the antenna. Thus, the control means 7 is used to compare the power of the radio-frequency signal to be transmitted from the output amplifier of the transmitter with the power of the radio-frequency signal reflected from the antenna, and on the basis of this comparison, it is deduced whether it is necessary to change the matching of the antenna. If a major part of the radio-frequency signal led to the antenna is reflected back, it is probably due to poor matching of the antenna. Thus, the control means 7 sets in the matching control line 8 a signal, whereby the matching of the matching means 9 of the antenna is changed.

After the control means 7 has set a new matching value in the matching means 9, it is possible to execute a new power measurement of the reflected radio-frequency signal and the radio-frequency signal to be

transmitted from the output amplifier. Now, if the measurement of the reflected power indicates that less of the radio-frequency signal is reflected in relation to the output power, it can be deduced that the matching is better than in the previous measurement. If necessary, it is also possible to try another matching alternative and to execute the above-described measuring and comparing operations to find out if a still better matching can be achieved with another matching, *i.e.* if the quantity of the reflected power can be reduced. Said adjustment of the matching can be made *e.g.* on the basis of the average value of the power measured over each transmission time slot, or on the basis of the average power measured over several such transmission time slots, wherein momentary changes in the environment of use of the antenna do not substantially affect the adjustment of the matching of the antenna.

In practical applications, an advantageous way to implement the matching means 9 and its control is to use PIN diodes as the switching means and capacitances and/or inductances as the matching means. By using PIN diodes in the switching of the high-frequency signal, *e.g.* the advantages is achieved that the antenna feeding line can be utilized in the control of the switches. Thus, a DC voltage to be supplied into the antenna feeding line is used to bias the diodes in a desired way, as will be presented below in this description.

The antenna of the wireless communication device according to the invention can be optimized at the designing stage either in view of either the standby state or the use position. Thus, the matching means 9 is used to change the matching of the antenna at the stage when the antenna is placed in another position. In view of the entirety, the aim in practical solutions is to make the matching means 9 as simple as possible, wherein a perfect matching is not necessarily achieved. On the other hand, a perfect matching normally requires a complex coupling, wherein the losses in the matching means may become greater than the benefit obtained with the matching. The appended Figs. 3a–3c show some advantageous solutions for implementing the matching means 9 and its control. In Figs. 3a and 3b, the antenna is optimized in the position of use of the wireless communication device, and the coupling illustrated in Fig. 3c is applicable for use in the

In the coupling of Fig. 3a, the matching means 9 consists of a capacitor C1. This capacitor C1 compensates the change in the resonance frequency, when the antenna is set in the standby state. Diodes D1 and D2 function as switching means in the following way. A positive DC voltage is led into the antenna supply line 10, wherein a bias current is passed through the first diode D1 and a first limiter L1 from the supply line to the ground potential. This bias current sets the first diode D1 in a conductive state, wherein a high-frequency current is passed from the supply line through the first diode D1 and the capacitor C1 to the antenna ANT. In a corresponding manner, when a negative DC voltage is set in the supply line 10, the bias current is passed from the ground potential through a second limiter L2 and the second diode D2 to the supply line 10, wherein the second diode D2 is biased, *i.e.* it is conductive, and, correspondingly, the first diode D1 does not conduct high-frequency power. Thus, the high-frequency current is passed from the supply voltage 10 through the second diode D2 to the antenna ANT. In this latter case, the capacitor C1 does not affect the matching of the antenna. The limiters L1, L2 prevent the short-circuiting of the high-frequency signal to the ground potential.

25 In the example coupling of Fig. 3b, only one diode D3 is used as a  
switching means and a capacitor C2 as the matching means. In case a  
DC voltage is not passed to the supply line 10, the diode D3 does not  
conduct high-frequency power either, wherein the high-frequency  
power to be led via the supply line 10 to the antenna is passed through  
the capacitor C2, wherein the antenna matching is composed of this  
30 capacitor C2. In a situation when a positive DC voltage is coupled into  
the supply line 10, the diode D3 starts to conduct high-frequency  
power, and thus the high-frequency signal to be transmitted is passed  
via the diode D3 to the antenna, and the capacitor C2 is short-circuited  
with respect to the high-frequency power. Thus, the capacitor C2 does  
35 not substantially affect the matching of the antenna. A limiter L3 leads  
the bias current to the ground potential and prevents the short-circuiting  
of the high-frequency signal to the ground potential. It is an advantage  
of this coupling of Fig. 3b with respect to the coupling of Fig. 3a that the

bias current is only needed during a call, when the antenna of the wireless communication device is in the use position.

Figure 3c shows an example coupling for such a wireless communication device in which the antenna is optimized according to the use position of the antenna. In the matching means according to this coupling, a bias current is supplied to the supply line 10 for a diode D4 in a situation when the antenna is in the standby position. Thus, the high-frequency power is passed through the diode D4 to the antenna. Also, an inductance L5 is formed between the matching means 9 and the antenna, preferably by the microstrip technique. Moreover, in the coupling of Fig. 3c, a second matching means used is a coil L4 in a situation when no bias voltage is passed into the supply line 10, wherein the high-frequency power is passed via the capacitor C3 and the coil L4 to the inductance L5 and further to the antenna ANT.

The respective position of the antenna ANT of the wireless communication device can be detected *e.g.* in such a way that the antenna is provided with a switch whose position is monitored. Thus, on the basis of a signal given by the switch, either the first or second functional state of the matching means is selected. Another alternative is to measure the power reflected from the antenna to deduce in which position the matching means 9 is placed each time. This function has been described above in the description of the present invention. Yet another alternative is to monitor the strength of the received signal and to try to find, by the control of the matching means 9, such a position in which the strength of the received signal is the greatest.

The adjustment of the antenna matching according to the present invention can be advantageously implemented also in such a way that a so-called proximity sensor 12 is used to measure the distance of the wireless communication device from obstacles in the vicinity. On the basis of this distance measurement, the matching of the antenna is adjusted. The distance measurement can be implemented *e.g.* so that the proximity sensor 12 in the wireless communication device MS comprises an infrared transmitter 12a and an infrared receiver 12b, as shown in Fig. 6. The infrared transmitter 12a is used to transmit an infrared signal (IR) from the wireless communication device MS to the



environment. The infrared receiver 12b is used to receive the reflected infrared signal, and *e.g.* the signal processing means 6 is used to measure the strength of the received signal and also the strength of the transmitted infrared signal, if necessary. Thus, it can be deduced from the ratio between the strength of the received signal and the strength of the transmitted infrared signal, whether there is an obstacle in the vicinity of the wireless communication device MS. Obstacles in the vicinity of the wireless communication device MS reflect a major part of the signal. If the measurement indicates that a major part of the transmitted infrared signal is reflected, it can be deduced that the wireless communication device is close to an obstacle, and the matching of the antenna is changed accordingly, *e.g.* by selected one of two or more matching circuits. In each application, it is preferably empirically established, how the distance and size of obstacles affects the quantity of the reflected infrared signal as well as how the antenna matching should be changed. Thus, the respective reference values to be used in the adjustment of the matching are advantageously stored in the wireless communication device MS. The reference values stored in the memory means MEM are preferably compared with the measurement result by the control means 7, which generates a control signal to set a suitable matching value in the matching means 9. This setting of the matching on the basis of the control signal is described elsewhere in this description, which is referred to in this context. It is obvious that instead of said infrared signal, it is also possible in the proximity sensor 12 to use another principle for measuring the distance, such as ultrasound.

Yet another embodiment of adjusting the antenna matching to be mentioned in this context is one in which the wireless communication device MS comprises a movable keypad cover 13 (Fig. 7) or the like. Such a keypad cover is usually placed to cover the keypad when there is no call going on. In a corresponding manner, for the time of a call, the keypad cover is placed in another position, off the keypad. This position of the keypad cover is examined *e.g.* with a switch means 14, wherein when the keypad cover is on the keypad, a first matching value of the matching means 9 is used in the antenna matching, and, correspondingly, when the keypad cover is off the keypad, a second matching value of the matching means 9 is used in the antenna matching.

Consequently, it is presumed here that during a call, the user keeps the wireless communication device MS close to his/her head, wherein the effect of the head in the antenna matching can be taken into account.

5 The method based on measuring the power reflected from the antenna is advantageous for example because the antenna matching can thus be made the best possible at the transmission frequency. Typically, the significance of the antenna matching is greater in transmission than in reception, because upon transmission from a wireless communication  
10 device, various unideal features affect the power consumption in the wireless communication device more than possible unideal features in the antenna matching at the receiving stage. Furthermore, making the antenna matching as good as possible is important in view of the stability of the power amplifier of the transmitter.

15 With reference to Figs. 4a and 4b, the following is a description on  
some advantageous coupling solutions for coupling a bias current to  
the supply line in the control of the matching means 9. The coupling of  
Fig. 4a is applicable for use in a situation in which the matching  
20 means 9 comprises one diode functioning as the coupling means, such  
as diode D3 in the coupling of Fig. 3b and diode D4 in the coupling of  
Fig. 3c. In the coupling of Fig. 4a, the means used for coupling a bias  
voltage is a transistor Q1. When the control means 7 sets in the control  
line 8 of the matching means a voltage value corresponding to the logi-  
25 cal 1 state, which is in practical solutions a value corresponding ap-  
proximately to the operating voltage, the transistor Q1 starts to conduct.  
Thus, at the transmission stage, the transistor Q1 switches a voltage  
from the operating voltage line VTX of the transmitter via a diode D5  
and a resistance R1 through a limiter L7 to the supply line 10, wherein  
30 the diode D4, D5 starts to conduct. In a corresponding manner at the  
receiving stage, the bias voltage is coupled from the operating voltage  
VRX of the receiver via a diode D6, a resistance R2, a transistor Q2,  
and the limiter L7 to the supply voltage line.

35 To set the matching means 9 in a second matching value, the control means 7 sets in the control line 8 of the matching means preferably a value corresponding to the logical 0 state, in practice ca. 0 V. Thus, the switching transistor Q1 does not conduct, wherein the bias voltage from

the supply line 10 is cut, and the diode D3 of the matching means does not conduct high-frequency power to the antenna. Thus, the second matching value of the matching means 9 is in use, *i.e.* the high-frequency power is passed to the antenna via the capacitor C1.

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The coupling solution according to Fig. 4b is suitable for use particularly in connection with such matching means, in which the selection of each matching means is controlled with a diode D1, D2. The coupling works in the following way. The coupling comprises two switching transistors

10 Q2, Q3, which are used to conduct to the supply line 10 the bias voltage required for achieving the matching needed each time. These switching transistors Q2, Q3 are coupled in series between the operating voltage  $V_{CC}$  and the ground potential. The output of the bias voltage is implemented from a pin 11 common to the transistors. From this

15 pin 11, the bias voltage is conducted via a resistance R5 and a limiter L8 to the supply line 10. This transistor coupling is implemented in such a way that only either of the transistors Q2, Q3 is conducting. Thus, the supply line 10 is supplied with either the voltage value substantially corresponding to the operating voltage, or the voltage value

20 substantially corresponding to the ground potential, *i.e.* in practice ca. 0 V. The control signal to these switching transistors Q2, Q3 is passed from the control line 8 of the matching means via a transistor Q4. In the transistor Q4 used as the switch, a grid G4 is used as the enabling input for the switch, wherein the switching transistor Q4 conducts in the

25 case that the operating voltage is coupled to either the transmitter or the receiver of the wireless communication device. The operating voltage of the transmitter is led to the grid G4 in the switching transistor Q4 via a diode D7, and in a corresponding manner, the operating voltage of the receiver is led via a diode D8 from the operating line RXP

30 of the receiver. In a case in which neither the receiver or the transmitter is operating, also matching is unnecessary, wherein the switching transistor Q4 does not conduct, which results in that also the transistors Q2, Q3 do not conduct.

35 The coupling arrangement of Fig. 4b works in connection with the matching coupling of Fig. 3a in the following way. When the transmitter or the receiver is on and the voltage value set in the control line 8 of the matching means is approximately 0 V, the switching transistors Q4, Q2

are conducting, wherein the supply line 10 has a DC voltage whose magnitude is approximately the operating voltage  $V_{CC}$ . Thus, the diode D1 of the matching means 9 is biased, *i.e.* it conducts a high-frequency power via the capacitor C1 to the antenna ANT. In a corresponding manner, when the control line 8 of the matching means has a voltage value corresponding approximately to the operating voltage  $V_{CC}$ , the switching transistors Q4, Q3 are in a conducting state and have the effect that the supply line 10 is close to the ground potential. Thus, the second diode D2 of the matching means 9 is biased and conducts a high-frequency power to the antenna ANT, *i.e.* the second matching value of the matching means 9 is in use. The purpose of the resistances R4, L5 is to set the connection line of the diodes D1, D2 on the antenna side at a voltage value which is approximately half of the operating voltage  $V_{CC}$ . Thus, a negative operating voltage does not need to be supplied to the supply line 10 to bias the second diode D2, but the biasing is accomplished by setting the voltage in the supply line at *ca.* 0 V. Also in a case that the switching transistor Q1 of the switching means does not conduct electricity, the biasing of the diodes D1, D2 is prevented with this resistance coupling R4, R5. In this situation, the pin common to the transistors Q2, Q3 is also at the voltage value which is approximately half of the operating voltage. Thus, the voltage over the diodes D1, D2 is *ca.* 0 V.

In the coupling of Fig. 4b, the transistor Q1 and the diodes D7, D8 are not necessarily needed, if there is a possibility in the control means 7 to set the connection line to be used in the control of the control line 8 of the matching means in a so-called high impedance state. Thus, it is examined in the application software of the control means 7, whether both the transmitter and the receiver are off, wherein this line is programmed into the high impedance state.

In practical solutions, the quantity of the bias current of the diodes is typically *ca.* 2 to 10 mA, depending *e.g.* on the type of the diodes D1—D4 as well as on the power levels used. In general, it can be stated that more bias current is needed in transmission than in reception, because a poorly biased PIN diode can produce harmonic distortion in a strong transmission signal. Also, losses in diodes are inversely proportional to the strength of the bias current. In the coupling

of Fig. 4a, the resistances R1, R2 can be used to set the bias currents suitably, and these resistances R1, R2 may have different resistance value, if unequal bias currents are required in transmission and reception.

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With the arrangement according to the present invention, it is possible to accomplish an optimal antenna matching in different use situations. This arrangement not only expands the service area of the wireless communication device but it also increases the talk time of the wireless communication device. For example, if the transmitter of the wireless communication device can reduce the transmission power by 2 dB as a result of better matching, the average power consumption of the power amplifier of the transmitter falls typically from 0.5 W to 0.32 W, presuming that the efficiency of the wireless communication device is ca. 50 %.

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It is obvious that in practical applications it is possible to use also more matching values in the matching means 9 than the two different matching values presented in the examples above. Thus, various switching arrangements can be used to select circuit solutions which affect the antenna matching and typically consist of capacitances and/or inductances dimensioned for different use situations.

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It is obvious that the above-presented signal processing operations can be implemented also *e.g.* in the application software of the control means 7 instead of the signal processing means 6.

The present coupling is not limited solely to the embodiments presented above but it can be modified within the scope of the appended claims.

Claims:

1. A system for matching an antenna (ANT) for a wireless communication device, **characterized** in that it comprises:
  - 5 — detecting means (4, 5, 12) to detect the matching of the antenna (ANT) and to generate a matching signal on the basis of the detected matching,
  - control means (7) to examine said matching signal, to determine the need for matching, and to generate a control signal on the basis of said matching signal, and
  - 10 — antenna matching means (9) to adjust the matching of the antenna (ANT) on the basis of said control signal.
2. The matching system according to claim 1, **characterized** in that
  - 15 said detecting means (4, 5, 12) comprise means (1, 5) to measure the radio power reflected from the antenna (ANT) and means (6) to generate a matching signal on the basis of the measurement on the reflected radio power.
3. The matching system according to claim 2, **characterized** in that
  - 20 said detecting means (4, 5, 12) also comprise means (1, 4) to measure the radio power to be supplied to the antenna (ANT) and means (6) to generate the matching signal on the basis of said measurement on the reflected radio power and said measurement on the radio power to be
  - 25 supplied to the antenna (ANT) of the wireless communication device.
4. A wireless communication device (MS) comprising at least an antenna (ANT), **characterized** in that the wireless communication device (MS) also comprises:
  - 30 — detecting means (4, 5, 12) to detect the matching of the antenna (ANT) and to generate a matching signal on the basis of the detected matching,
  - control means (7) to examine said matching signal, to determine the need for matching, and to generate a control signal on the basis of said matching signal, and
  - 35 — antenna matching means (9) to adjust the matching of the antenna (ANT) on the basis of said control signal.

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5. The wireless communication device (MS) according to claim 4, **characterized** in that said detecting means (4, 5, 12) comprise means (1, 5) to measure the radio power reflected from the antenna (ANT) and means (6) to generate a matching signal on the basis of the measurement on the reflected radio power.

6. The wireless communication device (MS) according to claim 5, **characterized** in that said detecting means (4, 5, 12) also comprise means (1, 4) to measure the radio power to be supplied to the antenna (ANT) and means (6) to generate the matching signal on the basis of said measurement on the reflected radio power and said measurement on the radio power to be supplied to the antenna (ANT) of the wireless communication device.

7. The wireless communication device (MS) according to claim 4, 5 or 5, **characterized** in that said detecting means (4, 5, 12) comprise means (12) to measure a distance and means (6) to generate the matching signal on the basis of said distance measurement.

8. The wireless communication device (MS) according to claim 7, **characterized** in that said means (12) to measure a distance comprise an infrared transmitter (12a) and an infrared receiver (12b).

9. The wireless communication device (MS) according to any of the claims 4 to 8, in which the antenna (ANT) is arranged to be placed in at least two different positions, **characterized** in that said detecting means (4, 5, 12) comprise means (12) to examine the position of the antenna (ANT) and means (6) to generate the matching signal on the basis of the position of the antenna (ANT).

10. The wireless communication device (MS) according to any of the claims 4 to 8, comprising at least a keypad cover (13) arranged to be placed in at least two different positions, **characterized** in that said detecting means (4, 5, 12) comprise means (14) to examine the position of the keypad cover (13) and means (6) to generate the matching signal on the basis of the position of the keypad cover (13).

11. A method for matching the antenna of a wireless communication device, **characterized** in that in the method, the matching of the antenna (ANT) is detected, a matching signal is generated on the basis of the detected matching, said matching signal is examined to deter-  
5 mined the need for matching the antenna (ANT), wherein a control signal is generated on the basis of said matching signal, and the matching of the antenna (ANT) is adjusted on the basis of said control signal.
12. The method according to claim 11, **characterized** in that said  
10 matching signal is generated by measuring the radio power reflected from the antenna (ANT).
13. The method according to claim 12, **characterized** in that said  
15 matching signal is generated by measuring also the radio power to be supplied to the antenna (ANT).
14. The method according to claim 11, **characterized** in that said  
20 matching signal is generated by measuring the distance of the wireless communication device from objects in the vicinity of the wireless communication device at the time.
15. The method according to claim 11, in which the antenna (ANT) can  
25 be placed in at least two different positions, **characterized** in that for generating said matching signal, the position of the antenna (ANT) is examined.

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### Abstract

The invention relates to a system for matching an antenna (ANT) for a wireless communication device, the system comprising: detecting means (4, 5, 12) to detect the matching of the antenna (ANT) and to generate a matching signal on the basis of the detected matching, control means (7) to examine said matching signal, to determine the need for matching, and to generate a control signal on the basis of said matching signal, and antenna matching means (9) to adjust the matching of the antenna (ANT) on the basis of said control signal. The invention relates also to a wireless communication device and a method for matching the antenna of a wireless communication device.

Fig. 2

006220 "T05/EE50

006260" T054E360

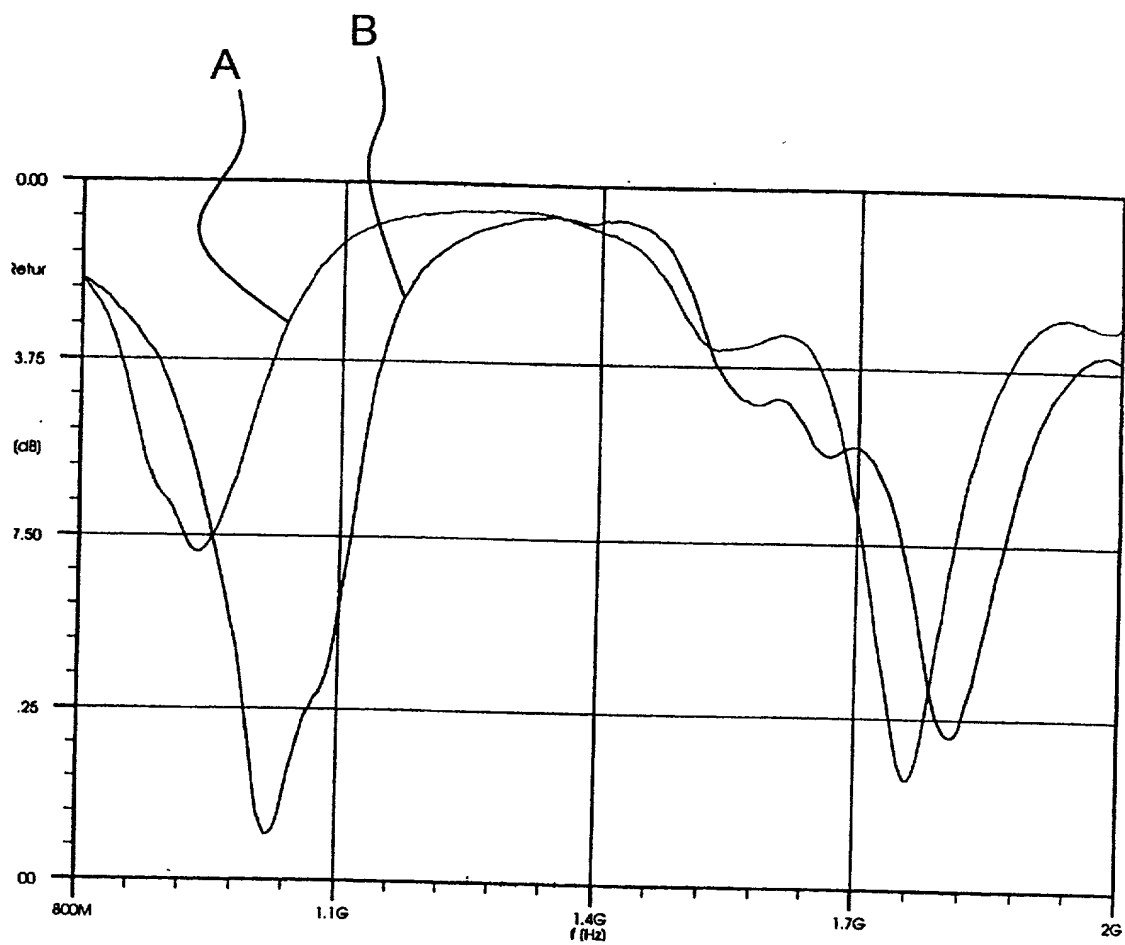


Fig 1

MS

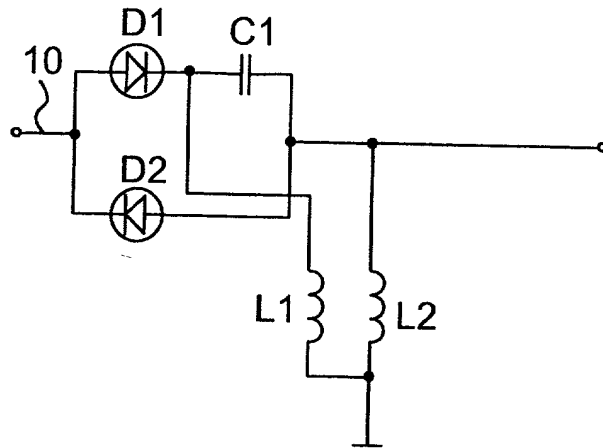


Fig 3a

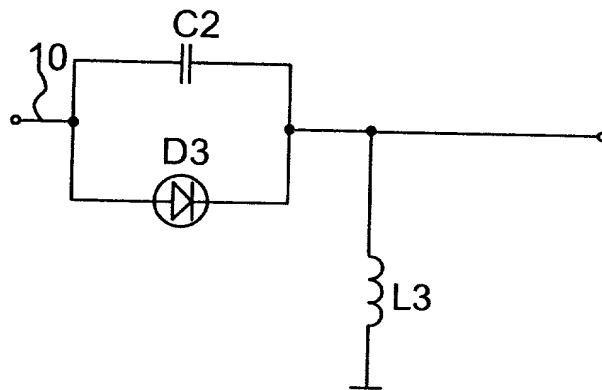


Fig 3b

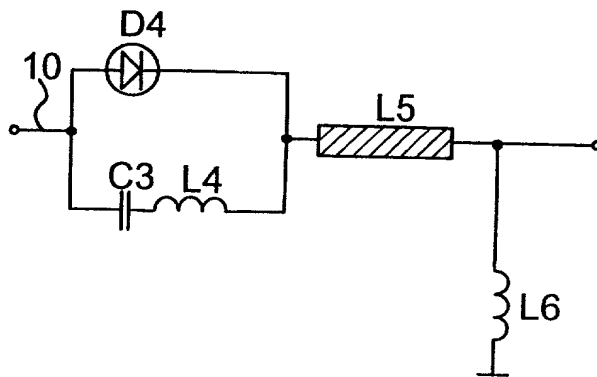


Fig 3c

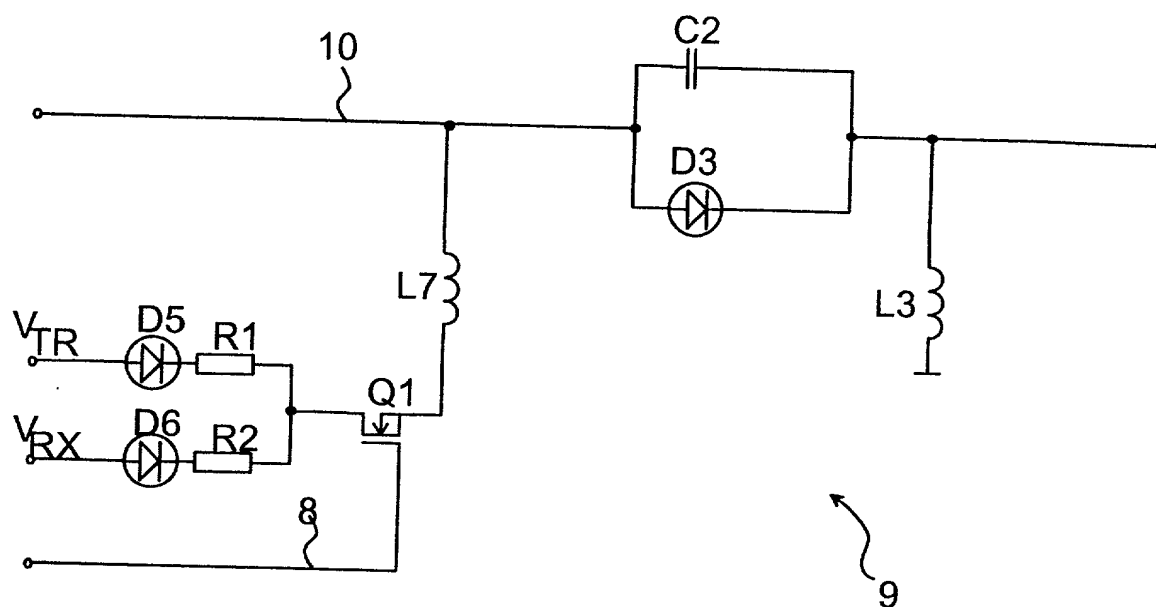


Fig 4a

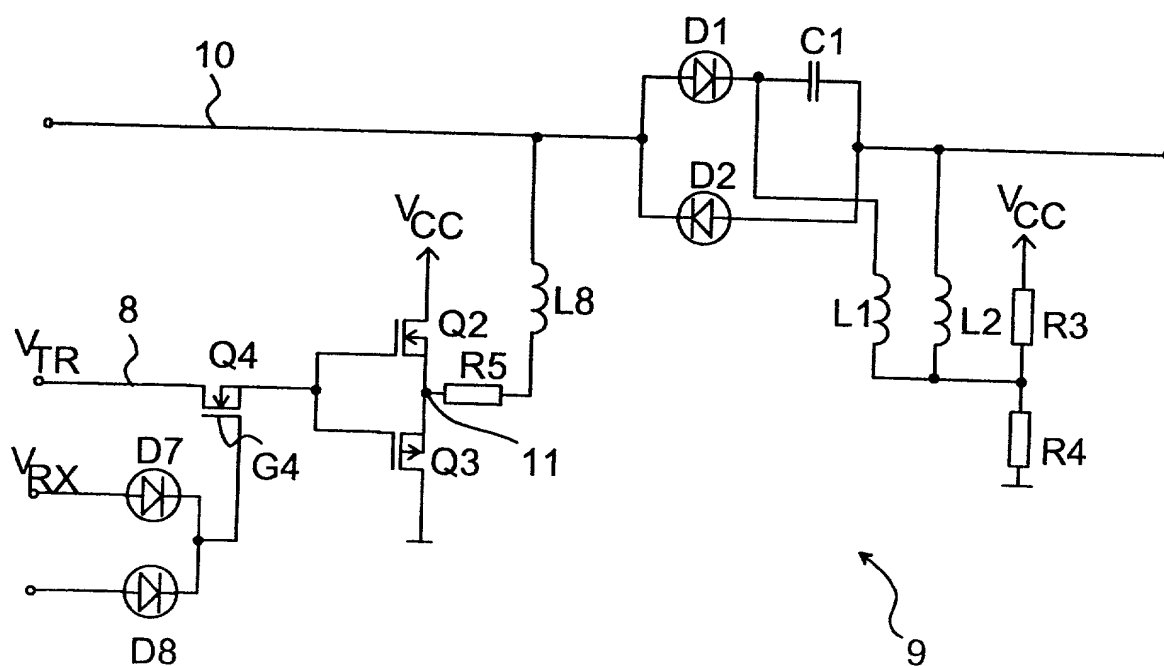


Fig 4b

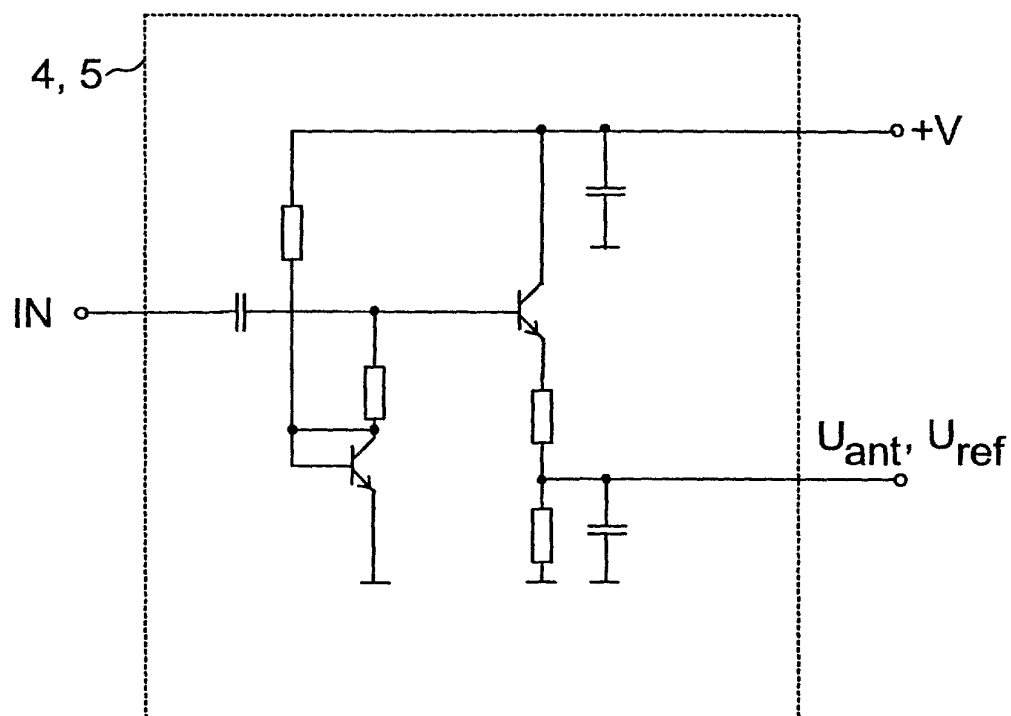


Fig 5

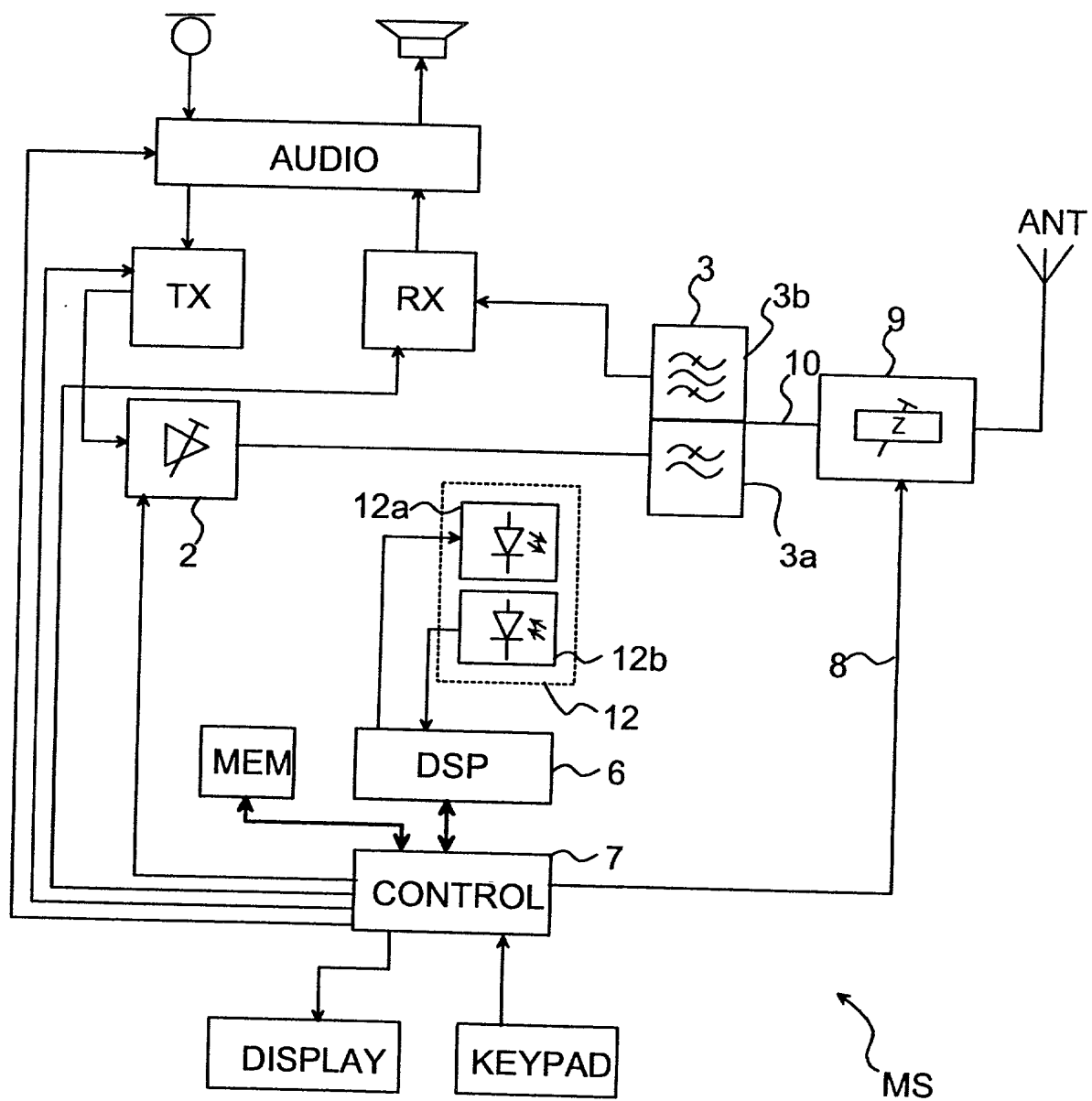


Fig 6

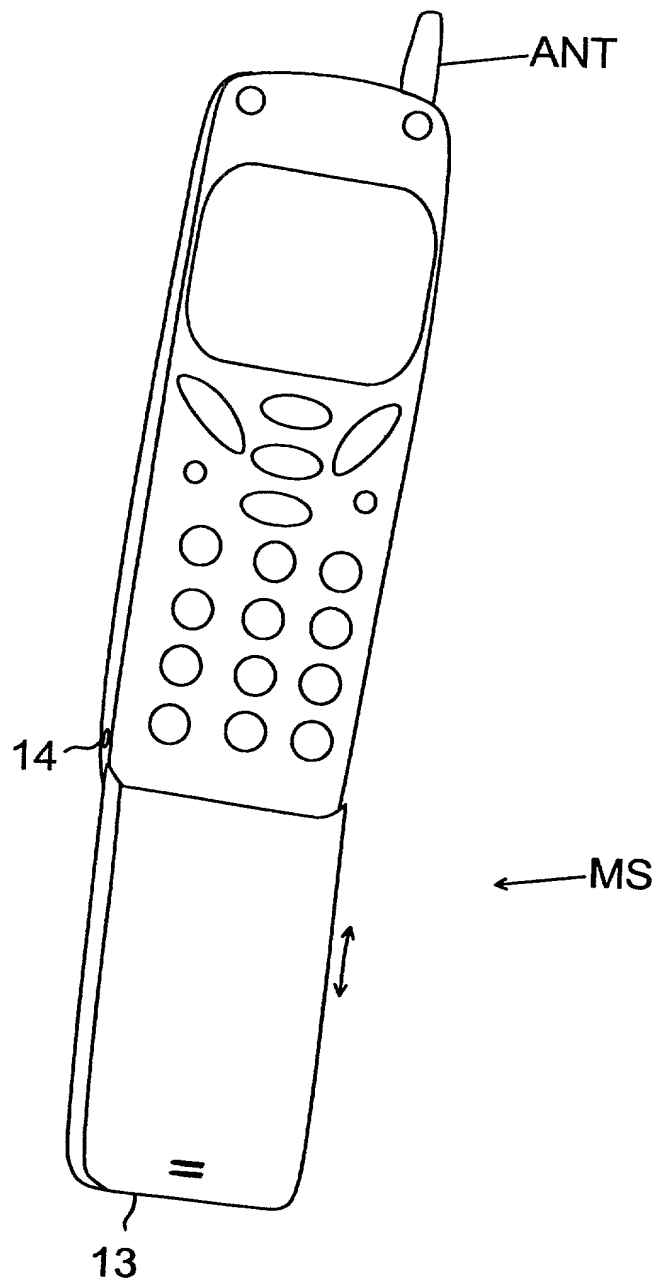


Fig 7



Attorney's Docket No. \_\_\_\_\_

PATENT

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## COMBINED DECLARATION AND POWER OF ATTORNEY

(ORIGINAL, DESIGN, NATIONAL STAGE OF PCT, SUPPLEMENTAL,  
DIVISIONAL, CONTINUATION OR C-I-P)

---

As a below named inventor, I hereby declare that:

### TYPE OF DECLARATION

This declaration is of the following type:

*(check one applicable item below)*

☒ original.

☐ design.

☐ supplemental.

NOTE If the declaration is for an International Application being filed as a divisional, continuation or continuation-in-part application, do not check next item; check appropriate one of last three items.

☐ national stage of PCT.

NOTE If one of the following 3 items apply, then complete and also attach ADDED PAGES FOR DIVISIONAL, CONTINUATION OR C-I-P.

☐ divisional.

☐ continuation.

☐ continuation-in-part (C-I-P).

### INVENTORSHIP IDENTIFICATION

**WARNING:** If the inventors are each not the inventors of all the claims, an explanation of the facts, including the ownership of all the claims at the time the last claimed invention was made, should be submitted.

My residence, post office address and citizenship are as stated below, next to my name. I believe that I am the original, first and sole inventor *(if only one name is listed below)* or an original, first and joint inventor *(if plural names are listed below)* of the subject matter that is claimed, and for which a patent is sought on the invention entitled:

### TITLE OF INVENTION

**System for matching an antenna for a wireless communication device**

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### SPECIFICATION IDENTIFICATION

the specification of which:

(complete (a), (b), or (c))

(a) ☒ is attached hereto

(b) ☐ was filed on \_\_\_\_\_ as ☐ Serial No. 0/  
) ☐ or ☐ Express Mail No., As Serial No. not yet known \_\_\_\_\_  
and was amended on \_\_\_\_\_ (if applicable).

NOTE: Amendments filed after the original papers are deposited with the PTO that contain new matter are not accorded a filing date by being referred to in the declaration. Accordingly, the amendments involved are those filed with the application papers or, in the case of a supplemental declaration, are those amendments claiming matter not encompassed in the original statement of invention or claims. See 37 CFR 1.67.

(c) ☐ was described and claimed in PCT International Application No. \_\_\_\_\_, filed on \_\_\_\_\_ and as amended under PCT Article 19 on \_\_\_\_\_ (if any).

### ACKNOWLEDGEMENT OF REVIEW OF PAPERS AND DUTY OF CANDOR

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information, which is material to patentability as defined in 37, Code of Federal Regulations, § 1.56,

(also check the following items, if desired)

- ☒ and which is material to the examination of this application, namely, information where there is a substantial likelihood that a reasonable Examiner would consider it important in deciding whether to allow the application to issue as a patent, and  
☐ in compliance with this duty, there is attached an information disclosure statement, in accordance with 37 CFR 1.98.

### PRIORITY CLAIM (35 U.S.C § 119(a)-(d))

I hereby claim foreign priority benefits under Title 35, United States Code, § 119(a)-(d) of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed.

(complete (d) or (e))

(d) ☐ no such applications have been filed.  
)

(e) ☒ such applications have been filed as follows.

NOTE: where item (c) is entered above and the International Application which designated the U.S. itself claimed priority check item (e), enter the details below and make the priority claim.

09537801-032900

**PRIOR FOREIGN/PCT APPLICATION(S) FILED WITHIN 12 MONTHS  
(6 MONTHS FOR DESIGN) PRIOR TO THIS APPLICATION  
AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. § 119(a)-(d)**

COUNTRY (OR INDICATE IF PCT)	APPLICATION NUMBER	DATE OF FILING (day, month, year)	PRIORITY CLAIMED UNDER 37 USC 119
<b>Finland</b>	<b>990687</b>	<b>29 March 1999</b>	<input checked="" type="checkbox"/> YES      NO <input type="checkbox"/>
			<input type="checkbox"/> YES      NO <input type="checkbox"/>
			<input type="checkbox"/> YES      NO <input type="checkbox"/>
			<input type="checkbox"/> YES      NO <input type="checkbox"/>
			<input type="checkbox"/> YES      NO <input type="checkbox"/>

**CLAIM FOR BENEFIT OF PRIOR U.S. PROVISIONAL APPLICATION(S)  
(34 U.S.C. § 119(e))**

I hereby claim the benefit under Title 35, United States Code, § 119(e) of any United States provisional application(s) listed below:

PROVISIONAL APPLICATION NUMBER

FILING DATE

_____ / _____	_____
_____ / _____	_____
_____ / _____	_____
_____ / _____	_____
_____ / _____	_____

**CLAIM FOR BENEFIT OF EARLIER US/PCT APPLICATION(S)  
UNDER 35 U.S.C. 120**

- ☐ The claim for the benefit of any such applications are set forth in the attached  
ADDED PAGES TO COMBINED DECLARATION AND POWER OF ATTORNEY  
FOR DIVISIONAL, CONTINUATION OR CONTINUATION-IN-PART (C-I-P)  
APPLICATION

006220" T052E550

**ALL FOREIGN APPLICATION(S), IF ANY, FILED MORE THAN 12 MONTHS  
(6 MONTHS FOR DESIGN) PRIOR TO THIS U.S. APPLICATION**

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**NOTE:** *If the application filed more than 12 months from the filing date of this application is a PCT filing forming the basis for this application entering the United States as (1) the national stage, or (2) a continuation, divisional, or continuation-in-part, then also complete ADDED PAGES TO COMBINED DECLARATION AND POWER OF ATTORNEY FOR DIVISIONAL, CONTINUATION OR C-I-P APPLICATION for benefit of the prior U.S. or PCT application(s) under 35 U.S.C. § 120.*

**POWER OF ATTORNEY**

I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith.

*(list name and registration number)*

Clarence A. Green	(24,622)
Harry F. Smith	(32,493)
Mark F. Harrington	(31,686)

*(check the following item, if applicable)*

☐ Attached, as part of this declaration and power of attorney, is the authorization of the above-named attorney(s) to accept and follow instructions from my representative(s).

---

**SEND CORRESPONDENCE TO**

Clarence A. Green  
Perman & Green, LLP  
425 Post Road  
Fairfield, CT 06430

**DIRECT TELEPHONE CALLS TO:**

*(Name and telephone number)*

Clarence A. Green  
(203) 250-1800

---

**DECLARATION**

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

## SIGNATURE(S)

NOTE: Carefully indicate the family (or last) name, as it should appear on the filing receipt and all other documents

### Full name of sole or first inventor

Olli \_\_\_\_\_ Talvitie \_\_\_\_\_  
(GIVEN NAME) (MIDDLE INITIAL OR NAME) FAMILY (OR LAST NAME)

Inventor's signature



Date 12 January 2000 Country of Citizenship Finland

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Post Office Address Satakunnankatu 63 B 20, FIN-33230 Tampere, Finland

### Full name of second joint inventor, if any

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Inventor's signature



Date 12 January 2000 Country of Citizenship Finland

Residence Annalankatu 11 A 2, FIN-33710 Tampere, Finland

Post Office Address Annalankatu 11 A 2, FIN-33710 Tampere, Finland

### Full name of third joint inventor, if any

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(GIVEN NAME) MIDDLE INITIAL OR NAME FAMILY (OR LAST NAME)

Inventor's signature



Date 12 January 2000 Country of Citizenship Finland

Residence Yrttikatu 17 D 8, FIN-33710 Tampere, Finland

Post Office Address Yrttikatu 17 D 8, FIN-33710 Tampere, Finland

(check proper box(es) for any of the following added page(s)  
that form a part of this declaration)

☒ **Signature** for fourth and subsequent joint inventors. *Number of pages added*

1

\* \* \*

☐ **Signature** by administrator(trix), executor(trix) or legal representative for deceased or  
incapacitated inventor. *Number of pages added*

\* \* \*

☐ **Signature** for inventor who refuses to sign or cannot be reached by person authorized  
under 37 CFR 1.47. *Number of pages added*

\* \* \*

☐ Added page for **signature** by one joint inventor on behalf of deceased inventor(s) where legal  
representative cannot be appointed in time. (37 CFR 1.47)

\* \* \*

☐ Added pages to combined declaration and power of attorney for divisional, continuation, or  
continuation-in-part (C-I-P) application.

☐ Number of pages added

\* \* \*

☐ Authorization of attorney(s) to accept and follow instructions from representative.

\* \* \*

(if no further pages form a part of this Declaration,  
then end this Declaration with this page and check the following item)

☐ This declaration ends with this page.

## SIGNATURE(S)

NOTE: Carefully indicate the family (or last) name, as it should appear on the filing receipt and all other documents

Full name of fourth joint inventor, if any

Masawan \_\_\_\_\_ Ramesh \_\_\_\_\_  
(GIVEN NAME) (MIDDLE INITIAL OR NAME) FAMILY (OR LAST NAME)  
Inventor's signature Ramesh Masawan  
Date 12 January 2000 Country of Citizenship Finland  
Residence Atomikatu 5 A 8, FIN-33720 TAMPERE, Finland  
Post Office Address Atomikatu 5 A 8, FIN-33720 TAMPERE, Finland

Full name of \_\_\_\_\_ joint inventor, if any

\_\_\_\_\_  
(GIVEN NAME) (MIDDLE INITIAL OR NAME) FAMILY (OR LAST NAME)  
Inventor's signature \_\_\_\_\_  
Date \_\_\_\_\_ Country of Citizenship \_\_\_\_\_  
Residence \_\_\_\_\_  
Post Office Address \_\_\_\_\_

Full name of \_\_\_\_\_ joint inventor, if any

\_\_\_\_\_  
(GIVEN NAME) (MIDDLE INITIAL OR NAME) FAMILY (OR LAST NAME)  
Inventor's signature \_\_\_\_\_  
Date \_\_\_\_\_ Country of Citizenship \_\_\_\_\_  
Residence \_\_\_\_\_  
Post Office Address \_\_\_\_\_